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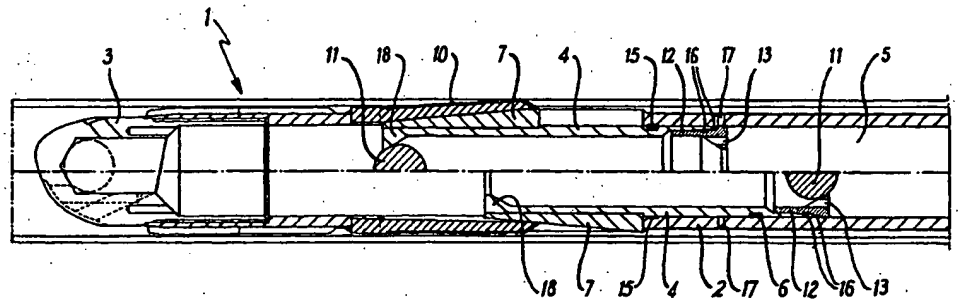
(54) Title: EXPANDABLE APPARATUS FOR DRIFT AND REAMING A BOREHOLE



(57) Abstract: An expandable reamer shoe is provided for use with expandable casing in a borehole. The reamer shoe has a number of reaming members in the form of blades which remain closed against the body of the shoe when inserted through casing, and can then be expanded to underream below the casing. Additionally, the expandable reamer shoe is made substantially of a drillable material so that the borehole can be extended beyond the point reached by the expandable reamer shoe.

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Expandable Apparatus for Drift and Reaming a Borehole

This invention relates to an expandable reamer shoe which can be used to drift and ream drilled well bores, as are typically used in oil and gas production.

When constructing a well bore, it is standard practice to drill in intervals. Firstly, a large surface hole is created into which casing is installed to act as a lining in the bore. Cement can then be displaced between the external surface of the casing and the interior of the well bore in order to structurally support the casing. In order to drill the next and deeper section of the bore it is common practice to use a smaller drill bit attached to a drill string which can be lowered through the previously installed casing in the first section of the bore. Consequently, the next section of the bore, and the casing installed within it, has a smaller diameter to that which is above it. Further sections of well are then lined with a length of even smaller casing which runs back to the surface and is inserted into the bore by the above described method. Several sections of hole may be drilled before the final back to surface section, near

the production zone, is drilled and lined with liner, which is hung inside the bore on the last string of casing, rather than being run back to the surface like the casing sections above it.

There have been a number of methods recently described whereby steel casing (US Patent No 5667011 and WO 93/25799) can be expanded after it has been run into a bore. Expandable casing overcomes the problem inherent to conventional casing whereby as a consequence of the normal installation procedure, the diameter of the sections of casing decreases with depth in the well-bore. However, if the well bore is not at the planned diameter when the casing is expanded in the hole which may occur for example, due to hole contraction after the drilling run, there is a danger that the next string of casing when expanded, will not go out to the full size, due to the restricted hole diameter outside the casing.

When requiring to drill a hole below the casing, of a size larger than the bore of the casing, it is standard practice to use a drill string with an underreamer and pilot bit. Underreamers are comprised of a plurality of expandable arms which can move between a closed position and an open position. The underreamer can be passed through the casing, behind the pilot bit when the underreamer is closed. After passing through the casing the underreamer can be opened in order to enlarge the hole below the casing. It is not feasible when running expanded casing, to drill down the casing using an underreamer attached, as underreamers are not drillable, that is they can only be used when there is a certainty that further sections of the bore will not be drilled, as

the subsequent drill bit or casing drill shoe would have to pass through the underreamer in order to advance. This is extremely difficult as underreamers are required to ream and remove hard rock material and typically comprise hard, resilient materials such as Tungsten Carbide or steel. Drilling through an in-place underreamer may result in damaging the drill bit or the casing drill shoe, adversely affecting the efficiency of any further drilling.

Other methods include the use of an expandable bit, rather than an underreamer with a pilot solid crown bit, and also a bi-centre bit.

It is therefore recognised in the present invention that it would be advantageous to provide a reamer shoe which can be used in conjunction with expandable casing and which is itself expandable, and can drift and ream a drilled section prior to expansion of the casing.

It is an object of the present invention to provide an expandable reamer shoe which can be attached to casing and which can drift and/or ream a previously drilled hole regardless of whether the casing is being advanced by rotation and/or reciprocation of the reamer shoe.

It is further object of the present invention to provide an expandable reamer shoe which can be used with either expandable casing or standard casing when desired.

It is a yet further object of the present invention to provide an expandable reamer which is constructed from a material which allows a casing drill shoe or drill bit to

drill through it such that the drill shoe or drill bit is not damaged and can progress beyond the point reached by the expandable reamer shoe within the well bore.

According to a first aspect of the present invention there is provided a reamer shoe for mounting on a casing string, the reamer shoe having a plurality of reaming members wherein said reamer shoe is constructed from a relatively soft drillable material, wherein the plurality of reaming members are moveable between a first and second position, and wherein the reaming members are closed in the first position and expanded in the second position.

Optionally the expandable reamer shoe can act as a drift.

Preferably the plurality of reaming members are in the form of blades.

Optionally each of the blades has a hard facing applied to the outer surface.

In one embodiment, the reaming members move from the first closed position to the second expanded position by virtue of the movement of an activating piston.

Most preferably said activating piston defines an internal bore.

Preferably movement of the activating piston is provided by an increase in hydrostatic pressure.

Preferably the increase in hydrostatic pressure is provided by an obstructing means within the internal bore of the activating piston.

Most preferably said obstructing means is a deformable ball or dart.

Preferably the reaming members are fully expanded when the ball communicates with a seat formation in the internal bore.

Preferably the ball is held inside the bore of the activating piston by a retainer ring.

Preferably the retainer ring has a plurality of by-pass ports which allow fluid and mud to pass through the retainer ring.

Optionally the activating piston or retainer ring is adapted to receive a retrieval tool such as a spear or overshot.

Preferably the activating piston has an external split ring mounted around the outside diameter.

Preferably the split ring can communicate with a groove in the body of the reamer shoe, wherein the activating piston is prevented from moving when the split ring is in communication with said groove.

Preferably a plurality of ramps are located externally to the activating piston.

Preferably the activating piston ramp segments, split ring, ball, retainer ring and float valve are drillable.

In a second embodiment concept of the present invention, the reaming members move from the first closed position to the second expanded position by virtue of a hydrodynamic pressure drop between the interior and exterior of the reamer shoe.

Most preferably said hydrodynamic pressure drop is created by one or more nozzles which may be attached to the lowermost end of the reamer shoe.

Preferably the reaming members are held in the first closed position by a plurality of leaf springs.

Preferably in the second expanded position the reaming members are locked in position by a first and second retaining block at either end.

Optionally the reamer shoe may contain a rupture means such as a burst disc, wherein upon rupturing, the rupture means permits the flow area of fluid from the interior of the reamer shoe to the exterior to be increased for ease of passage of cement, when cementing the casing, after reaming to bottom.

Optionally the expandable reamer shoe may have a cementing float valve fitted in the nose or the bore of the body.

According to a second aspect of the present invention there is provided a method of inserting expandable casing into a borehole, comprising the steps of;

a) running a first section of expandable casing into a pre-drilled borehole, expanding and then cementing (if required) the expandable casing in place,

b) underreaming under the in-place casing using a standard underreamer and pilot bit or an expandable bit or bi-centre bit,

c) running a second length of expandable casing through the in-place casing with an expandable reamer shoe to ream down by rotation and/or reciprocation to guarantee the hole is at the expected size

d) After reaming down, if needed, the expandable casing can be expanded and then cemented (if required) to create a slimhole or even a mono-bore well. The expandable reamer shoe, as well as having expandable blades, can also be designed to have its body expanded in the same manner as the casing above it.

The method may further comprise the step of running a subsequent section of casing through the in-place section of expandable casing after drilling through the apparatus of the first aspect to create a new hole or even to use a casing drill shoe to drill out the nose of the expandable reamer shoe for drilling and casing simultaneously.

In order to provide a better understanding of the invention, an example first embodiment of the invention will now be illustrated with reference to the following Figures in which;

Figure 1 illustrates a cross sectional view of an expandable reamer shoe in accordance with the present invention,
Figure 2 illustrates an external view of an expandable reamer shoe,
Figure 3 and 4 illustrate embodiments of the grooves which co-operate with the split ring of the activating piston, in an alternative cross sectional view expandable reamer shoe,
Figure 5 illustrates the nose of an expandable reamer shoe with a float valve included,
Figures 6 and 7 illustrate alternative retainer rings for use with of an expandable reamer shoe,
Figure 8 is a cross sectional view of an alternative second embodiment of an expandable reamer shoe,
Figure 9 and 10 illustrate the nose of the expandable reamer shoe of Figure 8 with a float valve option, and;
Figures 11 and 12 illustrate an alternative cross sectional view of the expandable reamer shoe of Figure 8.

Referring firstly to Figure 1, an expandable reamer shoe which can drift and ream a drilled section of well bore is generally depicted at 1 and is comprised of a cylindrical body (2) with an eccentric nose with ledge riding capability (3). The body (2) contains an activating piston (4) which is moveable and which defines an internal bore (5). The activating piston (4) has a split ring (6) which is fitted onto the outside diameter of the piston (4). The body (2) is made from steel and has hard facing reaming members (6) which can be seen in Figure 2 applied to the leading end for reaming the inner most section of the drilled hole.

Upon assembly of the tool (1), the activating piston (4) with the split ring (6) mounted thereon will be inserted into the bore (5) of the body (2). Simple service tooling is used to install the split ring (6) into the bore (5) of the body (2). The piston (4) would be slid down to the position shown on the lower side of the centre line of Figure 1. A plurality of ramp segments (7) would then be welded onto the outside of the piston (4) through slots (8) in the wall of the body (2). The slots (8) can be seen in more detail on the external view of the reamer shoe (1) seen on Figure 2.

It can be seen from Figures 3 and 4 that the piston (4) has six slots for the location of six ramp sections (7) each of which corresponds with one of six external blades (10). When the tool (1) is to be used as a reamer, the blades (10) have hard facing pre-applied, for example, hard or super hard metal or diamond. However when the tool (2) is to be used solely as a drift, the blades (10) will not need to have cutting grade hard facing. The piston (4), split ring (6) and ramp segments (7) are all made from a drillable material such as aluminium alloy. The blades (10) and body (2) are made from an material of medium hardness, such as alloy steel.

A deformable ball or dart (11) is then be dropped into the bore (5) of the piston (4). The ball or dart (11), which would typically be a rubber/plastic or rubber/plastic coated ball can be seen on the lower side of the centre line on Figure 1. A retainer ring (12) is then screwed into place, the retainer ring (12) also being made from a drillable material, such as aluminium alloy. The retainer ring (12) has holes (13) which allow

fluid and mud to pass through the retainer ring (12) when tripping the shoe (1) to the bottom of the well bore. The eccentric nose (3) of the tool (1) may have hard facing (6) applied on the outside and may also have a float valve (14), as seen in Figure 4. The eccentric nose (3) also has a bore which is large enough to accommodate the ball (11) and is typically off-centre to ensure that any subsequent drill bit (not shown) to be passed through the tool (1) can drill through the ball. This prevents the ball (11) from acting as a bearing upon which the drill bit will spin on.

The assembly (1) can then be fitted onto the end of an expandable casing (not shown) and run into a pre-drilled well bore to the end of the section of well bore which has already been drilled and cased. At the end of the existing casing string, the tool (1) is activated just after the new casing enters the new drilled hole section, ie with the tool (1) in the rat hole below the existing casing. This is achieved by applying power to mud pumps (not shown), attached at the surface and to the top of the pipe used for running the expandable casing. The flow of mud in the first few seconds seats the ball (11) into the piston (4), if it is not already in this location. By applying static pressure thereafter, the ball (11) will seal off the piston bore (5) and pressure will be applied across the full area of the external seal on the piston (4). Thus the piston (4) is encouraged to move down the bore (5) of the body (2) of the tool and in doing so deforms the plurality of blades (10) outwards, by virtue of each of the blades (10) communicating with its corresponding ramp segment(7). When the piston (4) is moved down the bore (5) to the body (2), the ball (11)

will rest in position in a seat (18) as shown on the upper side of the centre line in Figure 1. When the ball (11) rests on the seat (18) in the position seen on the upper side of the centre line in Figure 1, the piston (4) is stationary and the blades (10) are expanded to gauge size. In this position, the split ring (6) fits into a corresponding groove (15), which prevents the piston (4) from moving. The retainer ring (12) has seals (16) which are external to the retainer ring (12). The retainer ring (12) has two seals which fit into grooves (not shown) on the external surface of the retainer ring (12). When the seals (16) on the outside of the retainer ring (12) travel past corresponding holes or ports (17) in the body (2), there is a pressure drop at the surface which indicates that the blades (14) are at their gauge size.

By continuing to pump dynamically flowing fluid through the body (2) via the holes (17) to the outside, a dynamic pressure drop will be created. This will normally be lower than the static head which is required to push the piston (4) to this position. However on increasing the pump flow rate, the dynamic pressure head will be increased to a level above the static pressure head which is required to move the piston (4). As a consequence and at a pre-determined calculated level, the ball (11) will be pushed through the bore and the seat (18) of the piston (4) upon which the ball sits and into a seat in the eccentric nose (3). Mud can then flow through the nose (3). Rotation of the string can then take place and reaming to the bottom can commence.

Figure 5 illustrates a float valve (14) which can be incorporated into the nose (3) of the tool (1). The

float valve (14) allows mud and cement to pass through the nose (3) through the nozzles (19) in the nose (3) of the reamer shoe (1) to the bottom of the well, so that it can be displaced between the exterior surface of the casing and the interior surface of the well bore, to allow the casing to be cemented in place. However, the float valve (14) also ensures that cement cannot flow back into the reamer shoe through the nose although there would be some leakage through the pressure relief holes in the body adjacent to the retainer ring but the diametrical gap between the retainer ring and the body would be very small.

When reaming is completed, the nose (3), piston (4), split ring (6), ball (11) and retainer ring (12) and inside portion of the ramp segments can be drilled out with the drill bit (not shown), with a gauge diameter slightly smaller than the bore (5) of the body (2). The design of the ramp segments located in the wall of the body and welded to the piston prevents the piston and retainer ring spinning when being drilled out. The body (2) could also be expanded after drill out, by pushing a pig or plug from above the reamer shoe (1). Note that a seat for a hydraulic expansion seal dart could also be located in the reamer shoe including at the entry to the nose designed in this case so that the ball would still pass by or through it, with the ball seat in the guide end of the nose.

Figure 4 illustrates one embodiment of the invention, which allows the blades (10) to be retracted after use, wherein each of the blades (10) is adapted to correspond with a ramp section (7) by a dovetail groove (20). The

retainer ring (12) is provided with a profiled end which accommodates a retriever pulling tool (not shown), such as an overshot or spear. The retriever pulling tool can be used to pull the piston (4) back into its original position, hence pulling the blades (10) back into the body (2). Figure 5 illustrates a retainer ring (12) which is adapted to suit a spear (21). Figure 6 illustrates a retainer ring (12) which is adapted with an end to suit an overshot (22). It will be appreciated that de-latching of the overshot or spear will also be required in the event that it is desirable to pull back the casing string for any reason after reaming has commenced.

The tool (1) is designed to be welded while being assembled and manufactured, so that the amount of components within the internal bore (5) is minimised, and accordingly there are less internal parts which need to be drilled out for the next section of expandable casing.

The advantage of the above described embodiment lies in the fact that it is possible to drill through the expandable reamer shoe (1) after having reamed the expandable casing to the bottom, and following expansion and cementing of the expandable casing. However, it is also recognised in this invention that the reamer shoe (1) could be designed to act solely as a drift for the drilled hole or as a drift in addition to being a reamer shoe. Where the tool (1) is to be used as a drift, its dimensions are slightly smaller than that of the outside diameter of the drilled hole, and the tool will not comprise cutting grade hard facing. It is also

recognised that the tool (1) could also be used with standard casing as opposed to expandable casing.

An alternative second embodiment of the reamer shoe is shown in Figure 8, generally depicted at 23. The shoe (23) is made entirely from steel and is millable as opposed to drillable. The shoe (23) can also be retrieved back to the surface if required. The reamer shoe (23) can also be used with a final casing string, for example in a section which does not require drill-out.

The body (24) of the tool has three pockets each of which holds a blade (25) with hard metal or super hard metal or diamond, or other cutting grade material on the external surface, as shown in Figures 11 and 12. It will be appreciated that the cutting grade material will not be included on the blade (25) if the reamer shoe (23) is to be used as a drift only. The blades (25) are activated by the flow of fluid through the ports or nozzles (26) in the eccentric nose (27) of the tool (23) which creates a dynamic pressure drop between the inside and outside of the tool (23). This forces the blades (25) out against leaf springs (28) which are mounted in additional pockets along the length of the sides of the blades (25). Each blade (25) has a series of blade pistons (29) which are screwed into the base of the pockets of the body (24). The blades (25) are driven out to the gauge diameter by the dynamic pressure drop, against stop blocks (30) which are located at either end of each of the blades (25). The blades (25) are locked in place by the spring activated blocks (30), and reaming then commences to the bottom of the bore. A means to indicate that the blades

(25) are at the gauge size could be achieved by adding a pressure relief valve (not shown). The leaf springs (28) hold the blades (25) into the body (24) when the tool (23) is tripped into the hole. Figure 9 illustrates a cross section of the body (24) when the blades (25) are closed. Figure 10 illustrates the same cross section of the body (24) when the blades are expanded.

If the tool (23) is to be used on the final string of casing, the tool can be left in-situ without being drilled out. In addition, a float valve (31) can be fitted to the eccentric nose (27) of the tool (23) to aid cementing. Figure 10 illustrates the float valve (31) wherein the valve is closed thereby obturating the entry of fluid such as cement or mud from the body (24) of the tool (23) into the nose (27). Figure 12 shows the float valve (31) when open, which allows fluid to flow into the nose (27) when reaming. If a float valve (31) is not fitted to the nose (27), the nose (27) can be made integrally with the body (24).

The casing can be retrieved at any time while reaming, by pulling the casing string uphole until the blades (25) bear against the end of the shoe of the last casing string, and by applying tension to the string from the surface. This will push the blades (25) into the body (24) by shearing the spring activated blocks (30). A bursting disk (32) may also be incorporated into the body (24) of the tool to increase the flow area through the tool for cementing. It is envisaged that a bursting disk (32) will be incorporated into the shoe (23) if the nozzles (26) of the nose (27) are small. Incorporation of the bursting disk will ensure that a reasonably high

cross sectional flow area is available for cement to pass through. When using a burst disk it is likely that the nose will not incorporate a float valve as the cement could flow back in through the hole after the disc was burst. In this case the float valve would be fitted above the burst disc location.

An advantage of the present invention is that the reamer shoe can be expanded prior to the passage of expandable casing which will ensure that the casing can expand fully to the desired gauge size. A further advantage is that the reamer shoe may be drilled through by a subsequent drill bit or casing drill shoe with the first embodiment design. This allows further sections of a well-bore to be drilled below the region which has been lined by the expandable casing, without any damage to the drill bit. The expandable reamer shoe can also be advanced into the borehole by reciprocation and/or rotation.

Further modifications and improvements may be incorporated without departing from the scope of the invention herein intended.

CLAIMS

1. An expandable reamer shoe for mounting on a casing string, the shoe having a body upon which are arranged a plurality of reaming members wherein said reamer shoe is substantially constructed from a relatively soft drillable material, wherein the plurality of reaming members are moveable between a first and second position, and wherein the reaming members are closed in a first position and expanded in a second position.

2. An expandable reamer shoe as claimed in Claim 1, wherein the plurality of reaming members are in the form of blades.

3. An expandable reamer shoe as claimed in Claim 2, wherein each of the blades has a hard facing applied to an outer surface.

4. An expandable reamer shoe as claimed in any preceding Claim, wherein the reaming members move from the first closed position to the second expanded position by virtue of movement of an activating piston.

5. An expandable reamer shoe as claimed in Claim 4, wherein said activating piston defines an internal bore.

6. An expandable reamer shoe as claimed in Claim 4 or Claim 5, wherein movement of the activating piston is provided by an increase in hydrostatic pressure.

7. An expandable reamer shoe as claimed in Claim 6, wherein the increase in hydrostatic pressure is provided by an obstructing means within the internal bore of the activating piston.

8. An expandable reamer shoe as claimed in Claim 7, wherein said obstructing means is a deformable ball or dart.

9. An expandable reamer shoe as claimed in Claim 8, wherein the reaming members are fully expanded when the ball/dart communicates with a seat formation in the internal bore.

10. An expandable reamer shoe as claimed in Claim 8 or Claim 9, wherein the ball/dart is held inside the bore of the activating piston by a retainer ring.

11. An expandable reamer shoe as claimed in Claim 10, wherein the retainer ring has a plurality of by-pass ports which allow fluid and mud to pass through the retainer ring.

12. An expandable reamer shoe as claimed in any one of Claim 4 to Claim 11, wherein the activating piston is adapted to receive a retrieval tool such as a spear or overshot.

13. An expandable reamer shoe as claimed in Claim 10 or Claim 11, wherein the retainer ring is adapted to receive a retrieval tool, such as a spear or overshot.

14. An expandable reamer shoe as claimed in any of Claim 4 to Claim 13, wherein the activating piston has an external split ring mounted around an outside diameter.

15. An expandable reamer shoe as claimed in Claim 14, wherein the split ring can communicate with a groove in the body of the reamer shoe, wherein the activating piston is prevented from moving when the split ring is in communication with said groove.

16. An expandable reamer shoe as claimed in any one of Claim 4 to Claim 15, wherein a plurality of ramps are located externally to the activating piston.

17. An expandable reamer shoe as claimed in any one of Claim 1 to Claim 3, wherein the reaming members move from the first closed position to the second expanded position by virtue of a hydrodynamic pressure drop between an interior and exterior of the reamer shoe.

18. An expandable reamer shoe as claimed in Claim 16, wherein said hydrodynamic pressure drop is created by one or more nozzles attached to a lowermost end of the reamer shoe.

19. An expandable reamer shoe as claimed in any preceding Claim, wherein the reaming members are held in the first closed position by a plurality of leaf springs.

20. An expandable reamer shoe as claimed in any preceding Claim, wherein in the second expanded position the reaming members are locked in position by a first and second retaining block at each end of the reaming member(s).

21. An expandable reamer shoe as claimed in any preceding Claim, wherein the reamer shoe includes a rupture means such as a burst disc which permits increased fluid flow from an interior of the reamer shoe to the exterior of the reamer shoe.

22. An expandable reamer shoe as claimed in any preceding Claim, wherein the expandable reamer shoe includes a cementing float valve.

23. A method of inserting expandable casing into a borehole, comprising the steps of:

(a) running a first section of expandable casing into a pre-drilled borehole;

(b) expanding the first section of expandable casing in place;

(c) underreaming under the in-place first section of expanded casing using a standard underreamer and bit;

(d) running a second section of expandable casing through the first section of expandable casing with an expandable reamer shoe; and

(e) reaming down the borehole by rotation and/or reciprocation of the expandable reamer shoe to an expected size.

24. A method as claimed in Claim 23, wherein the method includes the step of drifting the expandable reamer shoe.

25. A method as claimed in Claim 23 or Claim 24, wherein the method includes the step of expanding the second section of expandable casing into the reamed borehole.

26. A method as claimed in any one of Claims 23 to 25, wherein the method includes the step of cementing the expandable casing.

27. A method as claimed in any one of Claims 23 to 26, wherein the expandable reamer shoe is as claimed in any one of Claims 1 to 22.

28. A method as claimed in any one of Claims 23 to 26, wherein the method includes the step of expanding the body of the expandable reamer shoe.

29. A method as claimed any one of Claims 23 to 27, wherein the method includes the step of drilling through the expandable reamer shoe prior to running a subsequent section of expandable casing through an in-place section of expandable casing.

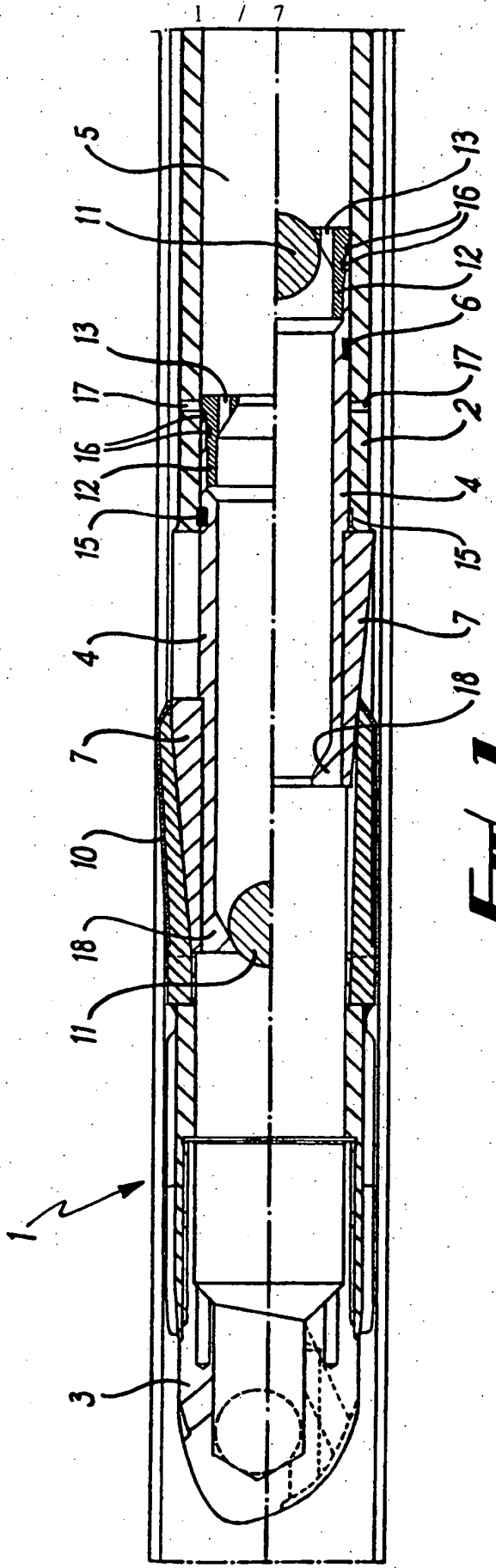

FIG. 1

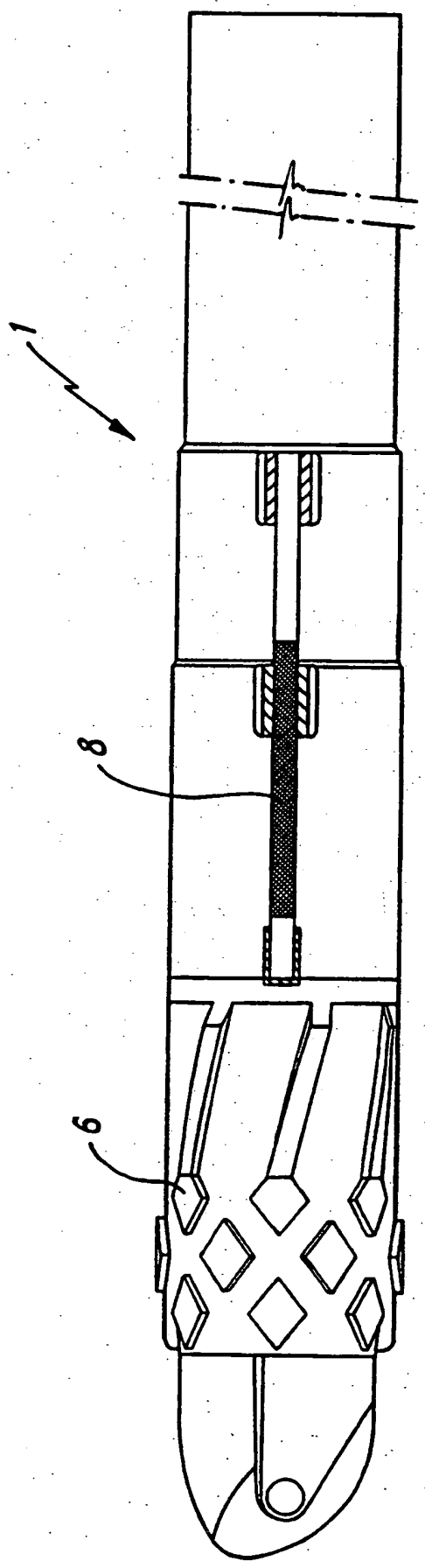

Fig.2

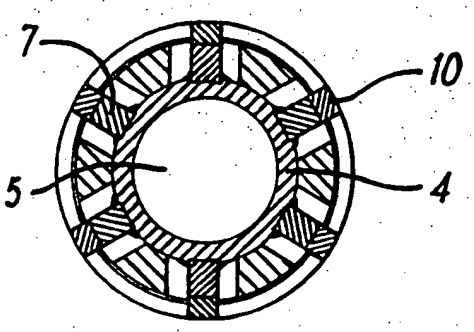

FIG. 3

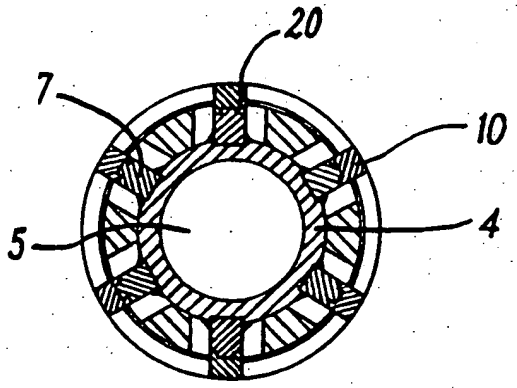

FIG. 4

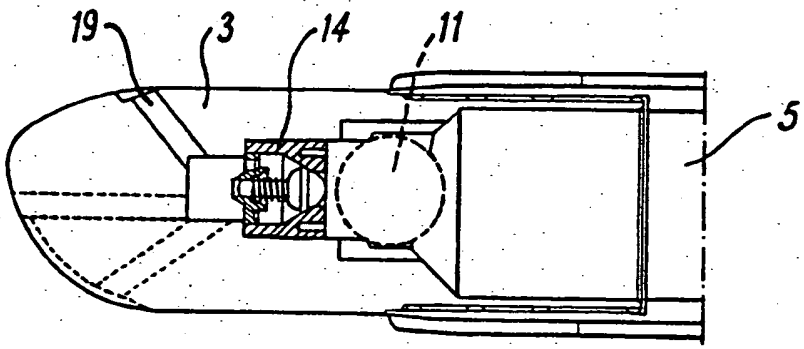

FIG.5

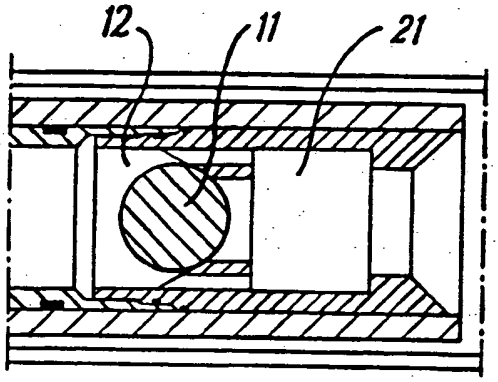

FIG.6

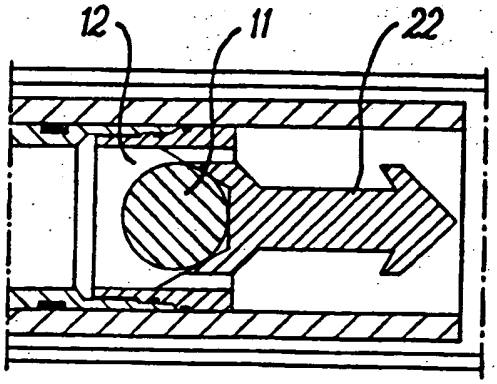

FIG.7

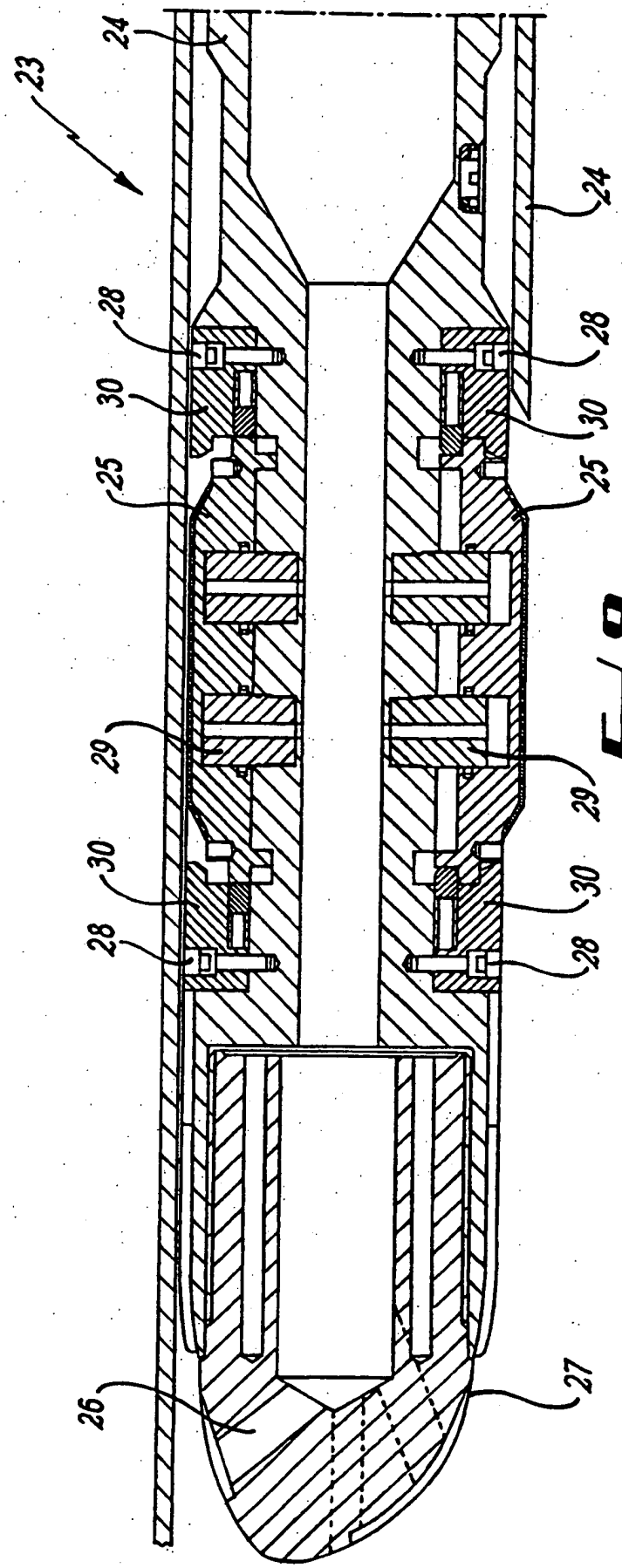

Fig.8

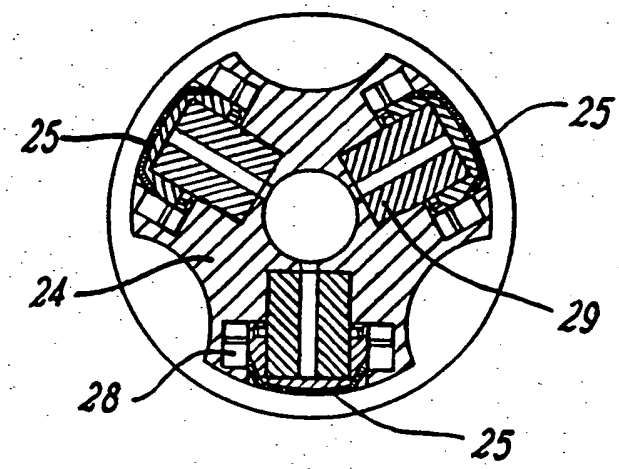

FIG. 9

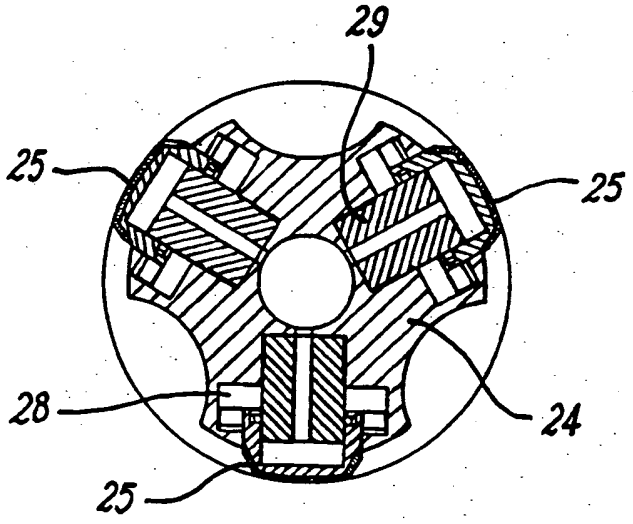

FIG. 10

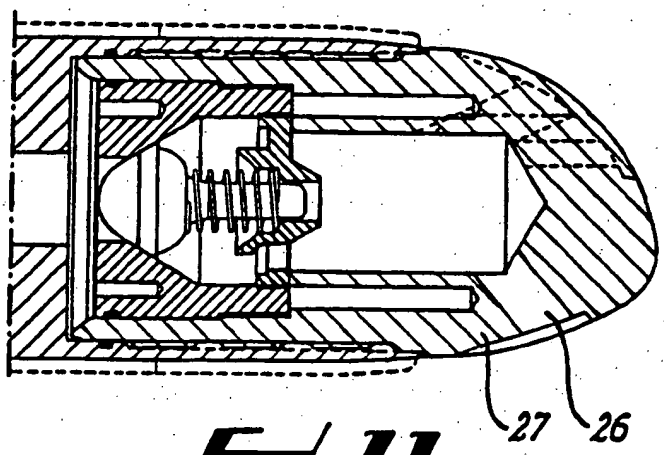

FIG. 11

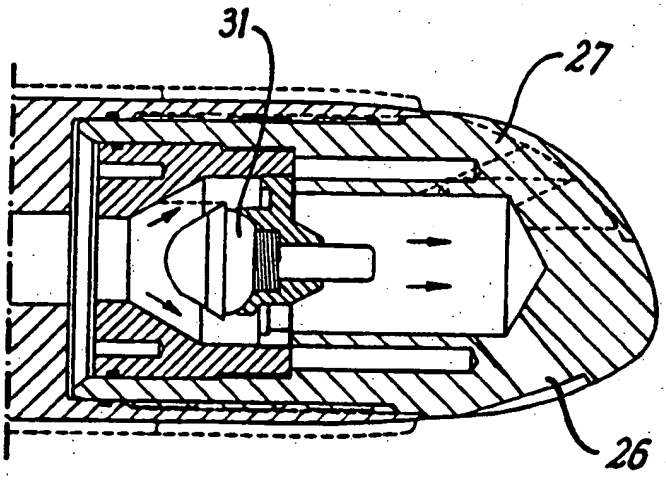

FIG. 12

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 01/01512

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B7/20 E21B17/14 E21B43/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3 552 510 A (BROWN CICERO C) 5 January 1971 (1971-01-05) column 6, line 35 - line 48; figures 1,2	1-8, 16-18, 20,23, 25-27
Y	WO 99 64713 A (WARDLEY MICHAEL ;BBL DOWNHOLE TOOLS LTD (GB)) 16 December 1999 (1999-12-16) page 8, line 11 -page 9, line 8	1-8, 16-18, 20,27
Y	US 5 361 859 A (TIBBITTS GORDON A) 8 November 1994 (1994-11-08) column 5, line 35 - line 46; figure 1	16

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11 July 2001	19/07/2001

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A	WO 96 28635 A (BRIT BIT LIMITED ;STRONG PHILLIP (GB); WARDLEY MICHAEL (GB)) 19 September 1996 (1996-09-19) page 9, line 12 - line 22	1-29
A	GB 2 333 542 A (DOWNHOLE PRODUCTS PLC) 28 July 1999 (1999-07-28) abstract	1-29

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
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